

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

--	--	--	--	--	--	--	--	--	--

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EEN3096 – COMMUNICATION ELECTRONICS

(TE / RE)

16 OCTOBER 2018

9.00 a.m - 11.00 a.m

(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages excluding cover page with 4 Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) The L -attenuator consists of 2 resistors arranged in the shape of L as shown in Fig.

Q1a. The input impedance, $Z_i = R_L$ and $K = \frac{V_{in}}{V_{out}}$. Derive the following components in

terms of voltage divider ratio K and R_L .

- (i) R_1
- (ii) R_2

[8 marks]

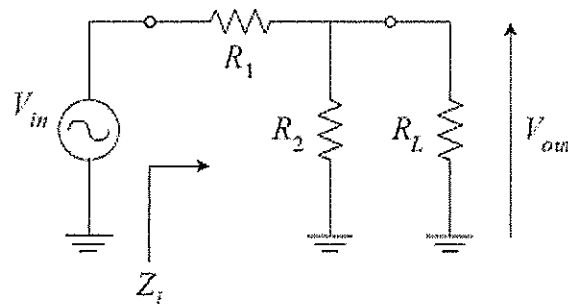


Fig. Q1a.

(b) Sketch the frequency response for the magnitude of impedance looking into a series RLC and a parallel RLC network, indicating the resonance frequency and the impedance during resonance.

[8 marks]

(c) The circuit in Fig. Q1b shows an L impedance matching network when $R_L > R_s$. Show

that $B = \frac{X_L \pm \sqrt{R_L / R_s} \sqrt{R_L^2 + X_L^2 - R_s R_L}}{R_L^2 + X_L^2}$

[9 marks]

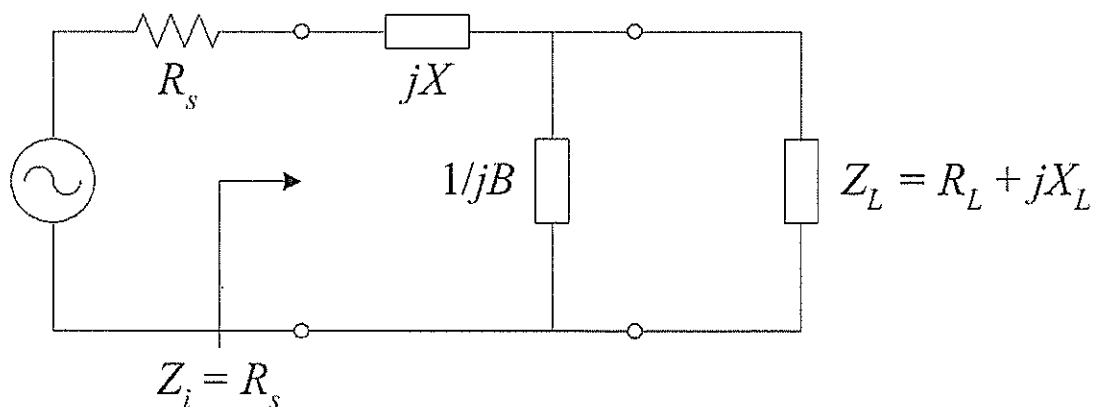


Fig. Q1b

Continued

Question 2

- (a) Explain THREE considerations in designing an RF amplifier. [6 marks]
- (b) Name TWO types of Neutralization methods in amplifier design. [2 marks]
- (c) Fig. Q2 shows the circuit diagram for a class A untuned amplifier using a 2N3904 npn-BJT as the active device. It has a L-C tank network with $L = 0.22 \mu\text{H}$ and $C = 46 \text{ pF}$. It is given that the transistor has the following parameters: $r_{bb'} = 25\Omega$, $h_{fe} = 200$, $V_{BE} = 0.7\text{V}$, $V_A = 40\text{V}$, $C_C = 5\text{pF}$ and $f_T = 300\text{MHz}$ at $T = 300\text{K}$.

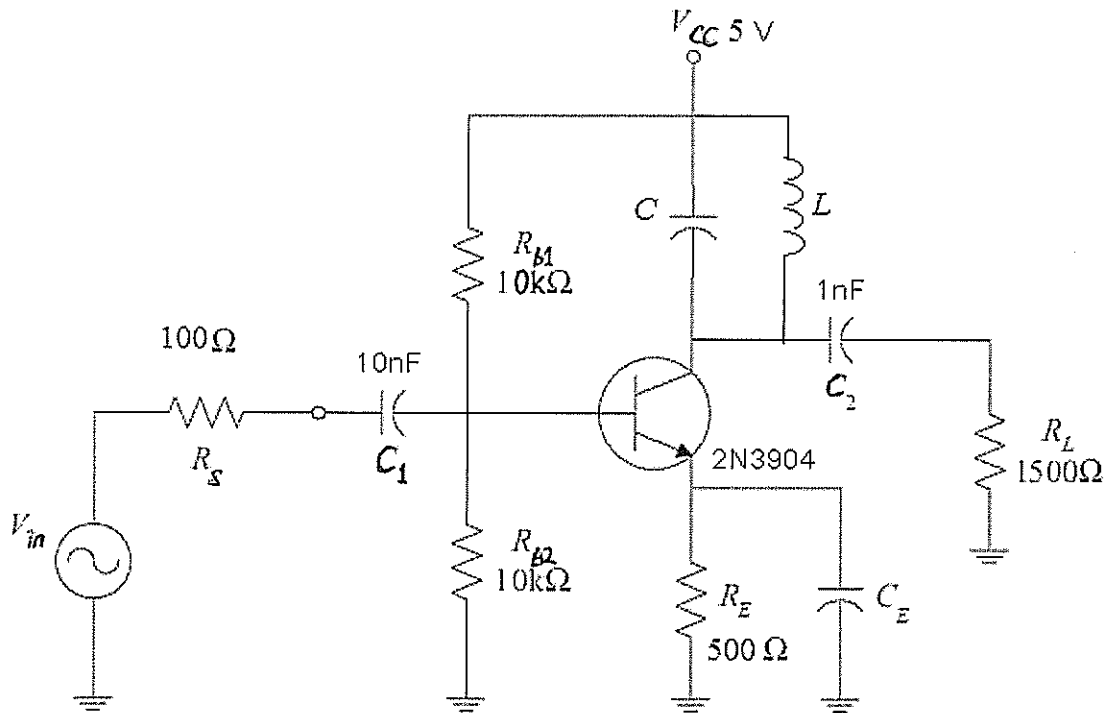


Fig. Q2

Applying the hybrid- π model and the Miller's approximation to the tuned amplifier circuit in Figure Q2, which is set to operate at a frequency $f_o = 50 \text{ MHz}$ and biased at $I_C = 4\text{mA}$,

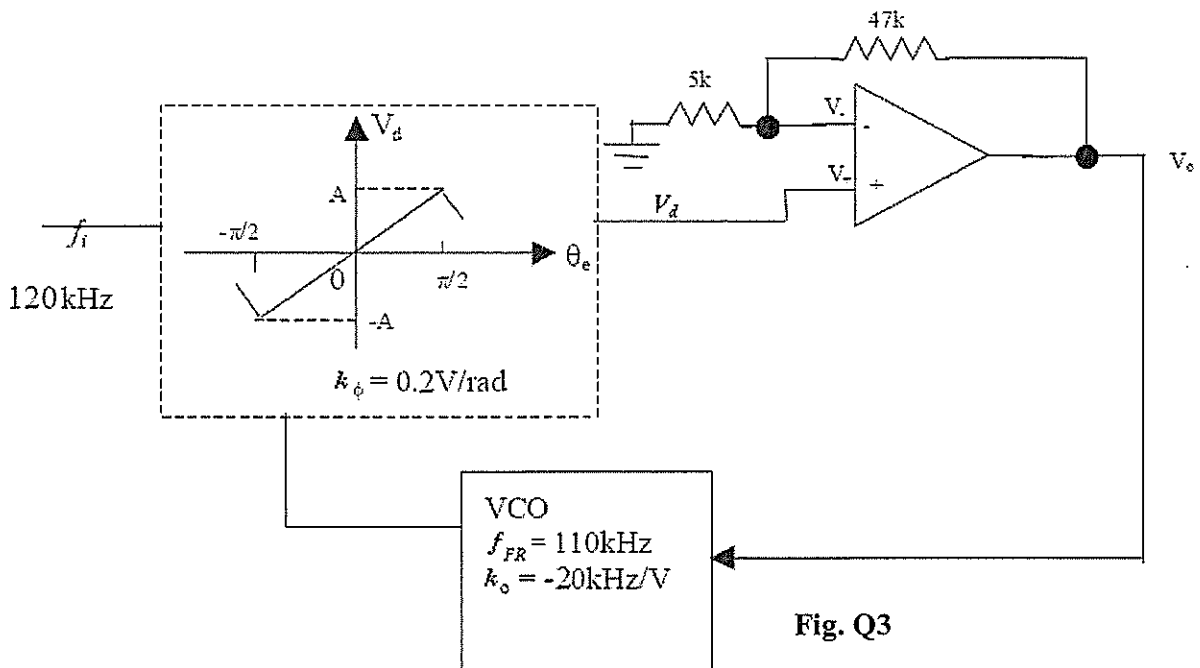
- (i) determine the values of the capacitor C_e , [4 marks]
- (ii) determine the effective voltage gain of the amplifier in dB [10 marks]
- (iii) determine the bandwidth of the amplifier [3 marks]

Continued

Question 3

(a) Fig. Q3 provides some information to design the static behavior of a PLL. Determine:

- (i) K_A of the amplifier. [1 mark]
- (ii) The loop gain K_L in units of Hz/rad and decibels. [2 marks]
- (iii) The loop gain K_v in units of s^{-1} and decibels. [2 marks]
- (iv) The VCO output frequency when the system is locked. [1 mark]
- (v) The static phase error, θ_e . [2 marks]
- (vi) The hold-in range, Δf_H . [2 marks]



(b) A simple PLL with Voltage Controlled Oscillator (VCO) loop gain $k_o = -5$ kHz/V, free-running frequency, $f_{FR} = 165$ kHz, phase detector gain $k_\phi = 0.5$ V/rad and amplifier gain $k_A = -10$ is used as an FSK demodulator. The input signal has space frequency $f_s = 180$ kHz and mark frequency $f_m = 150$ kHz. The baud rate is 5000 bit/s and the binary data is ...101...

- i) Sketch the output of the PLL $V_o(t)$. [13 marks]
- ii) Calculate the loop gain in dB at 1 rad/s [2 marks]

Continued

Question 4

- (a) Explain the term “Automatic Gain Control (AGC)” in radio receiver and describe the functionality of it in radio receiver.

[2 + 3 marks]

- (b) Sketch the Block diagram of a superheterodyne receiver with an automatic gain control (AGC).

[11 marks]

- (c) A double conversion receiver uses a first IF of 10.7 MHz and a second IF of 455 kHz, both with high tracking. For a signal is received at 40 MHz,

i) What are the LO frequencies? [3 marks]

ii) What are the outputs of first mixer? [3 marks]

iii) What are the signals going into the second mixer, and what signals come out of the second mixer?

[3 marks]

Continued

Appendix – Useful Formulas

1. L impedance matching network (when $R_L > R_S$):

$$B = \frac{X_L \pm \sqrt{R_L/R_S} \sqrt{R_L^2 + X_L^2 - R_S R_L}}{R_L^2 + X_L^2} \quad X = \frac{1}{B} + \frac{X_L R_S}{R_L} - \frac{R_S}{B R_L}$$

$$Q = \frac{|X|}{R_S}$$

2. L impedance matching network (when $R_L < R_S$):

$$B = \pm \frac{\sqrt{(R_S - R_L)/R_L}}{R_S} \quad X = \pm \sqrt{R_L(R_S - R_L)} - X_L \quad Q = R_S |B|$$

3. π impedance matching network:

$$L = L_1 + L_2 = \frac{R_L}{\omega_o} \left(\sqrt{R_S/R_L - 1} + \sqrt{R_L/R_L - 1} \right)$$

$$C_1 = \frac{1}{\omega_o R_S} \sqrt{\frac{R_S}{R_L} - 1} \quad C_2 = \frac{1}{\omega_o R_L} \sqrt{\frac{R_L}{R_L} - 1} \quad Q = \sqrt{\frac{R_S}{R_L} - 1} + \sqrt{\frac{R_L}{R_L} - 1}$$

4. RF Class A transistor amplifier (Hybrid π model of BJT)

$r_{bb'}$	The base-spreading resistance.
g_m	The transconductance. $g_m = \frac{dI_C}{dV_{BE}} = \frac{qI_C}{kT} \cong \frac{I_C \text{ (in mA)}}{25.875 \text{ mV}}$ at $T=300\text{K}$, q = electronic charge, $1.6 \times 10^{-19} \text{C}$
C_e	The emitter capacitance.
$r_{b'e}$	The input resistance. $r_{b'e} = \frac{dV_{BE}}{dI_B} = \frac{h_{fe}}{g_m}$
$r_{b'c}$	The collector to base resistance. $r_{b'c} = h_{fe} r_{ce}$
C_C	The collector capacitance.
r_{ce}	The output resistance. $r_{ce} \cong \frac{V_A}{I_C} = \frac{qV_A}{kTg_m}$ Where V_A is known as the Early voltage and I_C is the dc collector current.

Continued

5. High frequency Class A amplifier parameters:

(a) Voltage gain:

$$A_V = \frac{v_o}{v_{BE}} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + r_{b'e}} \frac{1}{1 + j\omega C_T \frac{r_{bb'} r_{b'e}}{r_{bb'} + r_{b'e}}}$$

In cases where $r_{bb'} \ll r_{b'e}$ then

$$A_V = \frac{v_o}{v_{BE}} = -\frac{g_m R_o}{1 + j\omega C_T r_{bb'}}$$

(b) Effective voltage gain (including the effect of source impedance R_S):

$$A_{VS} = \frac{v_o}{V_S} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + R_S + r_{b'e}} \frac{1}{1 + j\omega C_T \frac{(R_S + r_{bb'}) r_{b'e}}{R_S + r_{bb'} + r_{b'e}}}$$

In cases where $(R_S + r_{bb'}) \ll r_{b'e}$ then

$$A_{VS} = \frac{v_o}{V_S} = -\frac{g_m R_o}{1 + j\omega C_T (R_S + r_{bb'})}$$

Where $C_T = C_e + C_M$ and $C_M = \text{Miller capacitance } C_M = (1 + g_m R_o) C_C$

(c) Transition frequency

$$f_T = \frac{1}{2\pi} \frac{g_m}{C_e + C_C}$$

(d) Input impedance

$$Z_I = r_{bb'} + \frac{r_{b'e}}{1 + j\omega r_{b'e} C_T}$$

End of Paper